CLAIMS

What is claimed is:

1. A power transmission device comprising:

a rotary input member adapted to receive drive torque from a source of drive torque;

a rotary output member adapted to transmit drive torque to an output device;

a torque transmission unit operable for transferring drive torque from said input member to said output member, said torque transmission unit including a friction clutch operably disposed between said input member and said output member and a clutch actuator for controlling engagement of said friction clutch, said clutch actuator including a fluid pump, a rotary operator and a thrust mechanism, said rotary operator including first and second components defining an actuation chamber therebetween that is adapted to receive pressurized fluid from said pump, said first component being fixed for rotation with one of said input and output members and said second component adapted to rotate relative to said first component in response to the fluid pressure in said actuation chamber, and said thrust mechanism is operable for applying a clutch engagement force on said friction clutch in response to rotation of said second component relative to said first component; and

a control system including a motor driving said pump, a control valve disposed in a hydraulic circuit between said pump and said actuation chamber, and a control unit for controlling actuation of said motor and said control valve for regulating the fluid pressure supplied to said actuation chamber.

2. The power transmission device of Claim 1 wherein said control unit is operable to control actuation of said control valve and said electric motor for varying the magnitude of the fluid pressure supplied to said actuation chamber as a function of a rotary speed difference between said input and output members.

3. The power transmission device of Claim 1 wherein said control system further includes a pressure sensor which provides a signal to said control unit that is indicative of the value of the fluid pressure in said actuation chamber.

4. The power transmission device of Claim 1 wherein angular movement of said second component to a low pressure position relative to said first component causes said thrust mechanism to be located in a first position for applying a minimum clutch engagement force on said friction clutch, and wherein angular movement of said second component to a high pressure position relative to said first component causes said thrust mechanism to move to a second position for applying a maximum clutch engagement force on said friction clutch, said second component is moveable between its low pressure and high pressure positions due to the magnitude of the fluid pressure delivered from said pump through said control valve to said actuation chamber.

5. The power transmission device of Claim 4 wherein said torque transmission unit further includes a biasing mechanism for biasing said thrust mechanism toward its first position which, in turn, biases said second component of said rotary operator toward its low pressure position.

6. The power transmission device of Claim 1 wherein said first component of said rotary operator is a reaction ring having a cylindrical body segment and plurality of first lugs so as to define a plurality of channels therebetween, and wherein said second component of said rotary actuator is an actuator ring having a cylindrical body segment and a plurality of second lugs which extend into said channels so as to define a series of said actuation channels between adjacent pairs of said first and second lugs.

7. The power transmission device of Claim 6 wherein said actuator ring is fixed to a drive component of said thrust mechanism such that rotation of said drive component results in translational movement of a driven component of said thrust mechanism for controlling the magnitude of said clutch engagement force applied to said friction clutch.

8. The power transmission device of Claim 7 wherein said thrust mechanism is a ball ramp unit with a first cam plate as its drive component, a second cam plate as its driven component, and rollers retained in cam tracks formed between said first and second cam plates, said cam tracks configured to cause translational movement of said second cam plate in response to rotary movement of said first cam plate, and wherein said second cam plate is arranged to cause corresponding movement of a pressure plate relative to said friction clutch.

9. The power transmission device of Claim 8 wherein an increase in fluid pressure in said actuation chambers causes said actuator ring and said first cam plate to rotate in a first direction relative to said reaction ring for causing corresponding movement of said second cam plate from a first position toward a second position for axially moving said pressure plate from a released position toward a locked position relative to said friction clutch.

10. The power transmission device of Claim 9 wherein a decrease in fluid pressure in said actuation chambers causes said actuator ring and said first cam plate to rotate in a second direction relative to said reaction ring for causing movement of said second cam plate toward its first position for axially moving said pressure plate toward its released position.

11. The power transmission device of Claim 10 wherein a leakage flow path is provided in said actuator chambers so as to accommodate movement of said actuator ring in its second direction relative to said reaction ring.

12. The power transmission device of Claim 1 wherein said input member is a first shaft in a transfer case and said output member is a second shaft of said transfer case.

13. The power transmission device of Claim 1 wherein said input member is driven by a powertrain of a motor vehicle and said output member is connected to a differential unit of a drive axle assembly.

14. The power transmission device of Claim 1 defining a drive axle assembly having a differential unit interconnecting a pair of axleshafts, and wherein said input member is a differential carrier of said differential unit, said output member is one of said axleshafts, and said torque transmission unit is arranged to adaptively limit slip between said axleshafts.

15. A power transfer device for use in a motor vehicle having a powertrain and first and second drivelines, comprising:

a first shaft driven by the powertrain and adapted for connection to the first driveline;

a second shaft adapted for connection to the second driveline;

a torque transmission unit for transferring drive torque from said first shaft to said second shaft, said torque transmission unit including a friction clutch operably disposed between said first shaft and said second shaft, and a clutch actuator for engaging said friction clutch, said clutch actuator including a fluid pump, a rotary operator and a thrust mechanism, said rotary operator includes first and second components which define an actuation chamber that is adapted to receive pressurized fluid from said pump, said first component being fixed for rotation with one of said first and second shafts and said second component adapted to rotate relative to said first component in response to the fluid pressure in said actuation chamber, and said thrust mechanism is operable for applying a clutch engagement force to said friction clutch in response to rotation of said second component relative to said first component; and

a control system including a motor driving said pump, a control valve disposed in a hydraulic circuit between said pump and said actuation chamber, and a control unit for controlling actuation of said motor and said control valve so as to regulate the fluid pressure supplied to said actuation chamber.

16. The power transfer device of Claim 15 wherein said control unit is operable to control actuation of said motor and said control valve for adaptively varying the magnitude of the fluid pressure supplied to said actuation chamber as a function of a rotary speed difference between said first and second shafts.

17. The power transfer device of Claim 15 wherein said control system further includes a pressure sensor which provides a signal to said control unit that is indicative of the value of the fluid pressure in said actuation chamber.

18. The power transfer device of Claim 15 wherein angular movement of said second component to a low pressure position relative to said first component causes said thrust mechanism to be located in a first position for applying a minimum clutch engagement force on said friction clutch, and wherein angular movement of said second component to a high pressure position relative to said first component causes said thrust mechanism to move to a second position for applying a maximum clutch engagement for on said friction clutch, said second component is moveable between its low pressure and high pressure positions due to the magnitude of the fluid pressure delivered from said pump through said control valve to said actuation chamber.

19. The power transfer device of Claim 15 wherein said first component of said rotary operator is a reaction ring having a cylindrical body segment and a plurality of radially extending first lugs which define a series of channels therebetween, and wherein said second component is an actuator ring having a cylindrical body segment and a plurality of radially extending second lugs which extend into said channels so as to define a plurality of said actuation chambers between said first and second lugs, said actuator chambers in fluid communication with an outlet of said control valve, and wherein said fluid pump is operable to draw low pressure fluid from a sump and deliver high pressure fluid to said control valve such that selective control of said control valve results in rotary movement of said actuator ring relative to said reaction ring.

20. The power transfer device of Claim 19 wherein said actuator ring is fixed to a drive component of said thrust mechanism such that rotation of said drive component results in translational movement of a driven component of said thrust mechanism for exerting said clutch engagement force on said friction clutch.

21. The power transfer device of Claim 20 wherein said thrust mechanism is a ball ramp unit with a first cam plate as its drive component, a second cam plate as its driven component, and rollers retained in cam tracks formed between said first and second cam plates, said cam tracks are configured to cause translational movement of said second cam plate in response to rotary movement of said first cam plate for causing corresponding movement of a pressure plate relative to said friction clutch.

22. The power transfer device of Claim 21 wherein an increase in fluid pressure in said actuation chambers causes said actuator ring and said first cam plate to rotate in a first direction relative to said reaction ring for causing corresponding movement of said second cam plate for axially moving said pressure plate from a released position toward a locked position relative to said friction clutch, and wherein a decrease in fluid pressure in said actuation chambers causes said actuator ring and said first cam plate to rotate in a second direction relative to said reaction ring for causing movement of said second cam plate for axially moving said pressure plate toward its released position.

23. A power transfer device for use in a motor vehicle having a powertrain and first and second drivelines, comprising:

an input member adapted to receive drive torque from said powertrain;

a first output member adapted to provide drive torque to the first driveline;

a second output member adapted to provide drive torque to the second driveline;

a gearset operably interconnecting said input member to said first and second output members;

a torque transmission unit for limiting speed differentiation between said first and second output members, said torque transmission unit including a friction clutch operably disposed between any two of said input member and said first and second output members, and a clutch actuator for controlling engagement of said friction clutch, said clutch actuator including a fluid pump, a rotary operator and a thrust mechanism, said rotary operator includes first and second components defining an actuation chamber therebetween that is adapted to receive pressurized fluid from said pump, said first component is fixed for rotation with one of said input and output members and said second component adapted to rotate relative to said first component in response to the fluid pressure in said actuation chamber, and said thrust mechanism is operable for applying a clutch engagement force on said friction clutch in response to rotation of said second component relative to said first component; and

a control system including a control valve disposed in a hydraulic circuit between said pump and said actuation chamber and a control unit for controlling actuation of said control valve for regulating the fluid pressure supplied to said actuation chamber.

24. The power transfer device of Claim 23 wherein movement of said second component to a low pressure position relative to said first component causes said thrust mechanism to be located in a first position for applying a minimum clutch engagement force to said friction clutch, wherein movement of said second component to a high pressure position relative to said first component causes said thrust mechanism to move to a second position for applying a maximum clutch engagement force to said friction clutch, said second component being moveable between its low pressure and high pressure positions due to the magnitude of the fluid pressure delivered from said pump through said control valve to said actuation chamber.

25. The power transfer device of Claim 23 wherein said first component of said rotary operator is a reaction ring having a cylindrical body segment and a plurality of radially extending first lugs which define a series of channels therebetween, and wherein said second component is an actuator ring having a cylindrical body segment and a plurality of radially extending second lugs which extend into said channels so as to define a plurality of said actuation chambers between said first and second lugs, wherein said actuator chambers are in fluid communication with an outlet of said control valve, and wherein said fluid pump is operable to draw low pressure fluid from a sump and deliver high pressure fluid through said control valve to said actuation chambers for causing rotary movement of said actuator ring relative to said reaction ring.

26. The power transfer device of Claim 25 wherein said actuator ring is fixed to a drive component of said thrust mechanism such that rotation of said drive component results in translational movement of a driven component of said thrust mechanism for controlling the magnitude of said clutch engagement force applied to said friction clutch.

27. The power transfer device of Claim 26 wherein said thrust mechanism is a ball ramp unit with a first cam plate as its drive component, a second cam plate as its driven component, and rollers retained in cam tracks formed between said first and second cam plates, said cam tracks configured to cause translational movement of said second cam plate in response to rotary movement of said first cam plate, and wherein said second cam plate is arranged to cause corresponding movement of a pressure plate relative to said friction clutch.

28. The power transfer device of Claim 27 wherein an increase in fluid pressure in said actuation chambers causes said actuator ring and said first cam plate to rotate in a first direction relative to said reaction ring for causing said second cam plate to axially move said pressure plate from a released position toward a locked position relative to said friction clutch, and wherein a decrease in fluid pressure in said actuation chambers causes said actuator ring and said first cam plate to rotate in a second direction relative to said reaction ring for causing said second cam plate to axially move said pressure plate toward its released position.

29. A torque transmission unit for use in a motor vehicle having a powertrain and a driveline, comprising:

an input member driven by the powertrain;

an output member driving the driveline;

a clutch pack operably disposed between said input and output members;

a pressure plate moveable relative to said clutch pack between a first position and a second position, said pressure plate is operable in its first position to apply a minimum clutch engagement force on said clutch pack and said pressure plate is operable in its second position to apply a maximum clutch engagement force on said clutch pack;

a clutch actuator for controlling movement of said apply plate between its first and second positions, said clutch actuator including a fluid pump, a rotary actuator and a thrust mechanism, said rotary operator including first and second components that are coaxially arranged to define an actuation chamber therebetween which is adapted to receive pressurized fluid from said pump, said first component of said rotary operator is fixed for rotation with one of said input and output members and said second component is adapted to rotate relative to said first component in response to the fluid pressure in said actuation chamber, and said thrust mechanism is operable to move said pressure plate between its first and second positions in response to rotation of said second component relative to said first component; and

a control system including a control valve disposed in a hydraulic circuit between said pump and said actuation chamber and a control unit for controlling actuation of said control valve for regulating the fluid pressure supplied to said actuation chamber.

30. The power transmission device of Claim 29 wherein said control unit is operable to vary the magnitude of the fluid pressure supplied to said actuation chamber as a function of a rotary speed difference between said input and output members.

31. The power transmission device of Claim 29 wherein said control system further includes a pressure sensor which provides a signal to said control unit that is indicative of the value of the fluid pressure in said actuation chamber.

32. The torque transmission unit of Claim 29 wherein angular movement of said second component to a first position relative to said first component causes said thrust mechanism to locate said pressure plate in its first position, and wherein angular movement of said second component to a second position relative to said first component causes said thrust mechanism to locate said pressure plate in its second position, wherein movement of said second component from its first position toward its second position is caused by an increase in the fluid pressure delivered by said control valve to said actuation chamber.

33. The torque transmission unit of Claim 29 wherein said first component of said rotary operator is a reaction ring having a cylindrical body segment and plurality of first lugs so as to define a plurality of channels therebetween, and wherein said second component of said rotary actuator is an actuator ring having a cylindrical body segment and a plurality of second lugs which extend into said channels so as to define a series of actuation channels between adjacent pairs of said first and second lugs.

34. The torque transmission unit of Claim 33 wherein said actuator ring is fixed to a drive component of said thrust mechanism such that rotation of said drive component results in translational movement of a driven component of said thrust mechanism for controlling the magnitude of said clutch engagement force applied by said pressure plate to said friction clutch.

35. The torque transmission unit of Claim 34 wherein said thrust mechanism is a ball ramp unit with a first cam plate as its drive component, a second cam plate as its driven component, and rollers retained in cam tracks formed between said first and second cam plates, wherein said cam tracks are configured to cause translational movement of said second cam plate in response to rotary movement of said first cam plate, and wherein said second cam plate is arranged to cause corresponding translational movement of said pressure plate relative to said friction clutch.

36. The torque transmission unit of Claim 35 wherein an increase in fluid pressure in said actuation chambers causes said actuator ring and said first cam plate to rotate in a first direction relative to said reaction ring for causing said second cam plate to axially move said pressure plate from a released position toward a locked position relative to said friction clutch, and wherein a decrease in fluid pressure in said actuation chambers causes said actuator ring and said first cam plate to rotate in a second direction relative to said reaction ring for causing said second cam plate to axially move said pressure plate toward its released position.

37. A drive axle assembly for use in a motor vehicle having a powertrain and a pair of wheels, comprising:

an input shaft adapted to receive drive torque from the powertrain;

a pair of axleshafts adapted for connection to the pair of wheels;

a differential having an input member and a pair of output members connected to said pair of axleshafts;

a pinion shaft driving said input member of said differential;

a torque transmission unit operable for transferring drive torque from said input shaft to said pinion shaft, said torque transmission unit including a friction clutch operably disposed between said input shaft and said pinion shaft and a clutch actuator for controlling engagement of said friction clutch, said clutch actuator including a fluid pump, a rotary operator and a thrust mechanism, said rotary operator includes first and second components which define an actuation chamber therebetween, said first component is fixed for rotation with one of said input shaft and said pinion shaft and said second component is adapted to rotate relative to said first component in response to the fluid pressure in said actuation chamber, and said thrust mechanism is operable for applying a clutch engagement force to said friction clutch in response to rotation of said second component relative to said first component; and

a control system including a motor driving said pump, a control valve disposed in a hydraulic circuit between said pump and said actuation chamber, and a control unit for controlling actuation of said motor and said control valve for regulating the fluid pressure supplied to said actuation chamber.

38. The drive axle assembly of Claim 37 wherein said control unit is operable to control actuation of said motor and said control valve for adaptively varying the magnitude of the fluid pressure supplied to said actuation chamber as a function of a rotary speed difference between said pinion shaft and said input shaft.

39. The drive axle assembly of Claim 37 wherein said control system further includes a pressure sensor which provides a signal to said control unit that is indicative of the value of the fluid pressure in said actuation chamber.